Agronomic and environmental constraints found in on-farm production of switchgrass in the Chariton River Valley, Iowa

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Conceptually, growing switchgrass for biomass should be a straightforward farming endeavor, with agronomists simply adapting well-established production knowledge gathered from forage research. Pragmatically, this has not proven to be so - at least not in the Chariton River Valley, which is a 160,000-hectare watershed in south central Iowa. The hilly, erosive landscapes consist of numerous soils containing high clay contents and typically having poor internal drainage and acidic sola ?1?. These landscape and soil limitations resulted in extensive land enrollment (i.e., about 12% of the watershed) in the USDA Conservation Reserve Program (CRP) and corollary establishment of switchgrass fields during the 1980's and 1990's ?see 2?. The objective of this paper is to document and discuss observed agronomic and environmental constraints in switchgrass production within the Chariton Valley. This objective is met by synthesizing results from two related on-farm studies.

The first study examined biomass productivity and quality across mature, established switchgrass fields ('Cave-In-Rock' cultivar) originally planted as part of the CRP. Its objective was to determine the effects of harvest dates, landscape position, and nitrogen fertilizer rate on switchgrass yield and biomass quality traits. Experimental design was a randomized complete block using two sites (one having six replications, the other having five replications). Plot size varied in order to capture maximize landscape variability. A typical plot was about 60 m wide by 30 to 100 m long, with the length beginning on a summit and extending across the backlsope and onto the footslope. Nitrogen fertilizer treatments were 0, 56, 112, and 224 kg N ha^{-1} (as ammonium nitrate). These were applied to 15 m wide strips within each plot. Yield data were collected in 1998 and 1999 using a late fall harvest treatment.

Table 1: Comparison between 1998 and 1999 for selected switchgrass biomass properties across two locations, four nitrogen fertilization levels and three landscape positions.

		Year			
Trait	Unit	1998	1999	Mean	LSD (5%)
Biomass Yield	Mg ha^{-1}	2.9	3.9	3.4	0.2
Canopy Height (August)	cm	114	144	129	5
Lodging	%	6	11	8	5
Fiber Properties					
NDF	g kg^{-1}	648	710	680	9
ADF	g kg^{-1}	358	414	386	10
ADL	g kg^{-1}	56	71	63	2
Hemicellulose	g kg^{-1}	290	296	293	2
Cellulose	g kg^{-1}	302	343	322	9
Total N	g kg^{-1}	7.3	5.5	6.4	0.5
Ash	g kg^{-1}	65	56	60	2

Biomass yields averaged 3.4 Mg ha^{-1}, with the second year yield being significantly greater than the first year (Table 1). This reflects both better management and a better (although not good) growing season.

These yields are quite low relative reports from elsewhere in Iowa and the USA although many of those reports are from research plots, not farmers' fields. ?e.g., see 3?. The low yields found in this study are interpreted as reflecting a combination of poor weather each year, the inherent soil limitations across these sites, and, especially, the pre-existing stand problems associated with a paucity of field management prior to the initiation of these trials. These interpretations are supported by data from 13 other fields and 45 transects. Those fields from across the Chariton River Valley had yields ranging from 1.5 to 16.4 Mg ha^{-1}, with the mean being 6.6 Mg ha^{-1}. Each of these 13 fields and 45 transects had 64 kg ha^{-1} nitrogen fertilizer applied as well as aggressive weed management.

Biomass yields, lodging, and plant height increased linearly and proportionally to nitrogen fertilizer rates both years (data not shown). Nitrogen treatments resulted in no differences in cell wall components or mineral composition. Landscape position influenced yields albeit not as greatly as expected. Summits had higher yields than the back- and footslopes. These landscape-yield trends indicate why many farms in the Chariton River Valley dedicate their summits to higher value row-crop production and relegate their back- and footslopes to lower value pasture.

The second study examined in-field environmental quality associated with long-term production of switchgrass in the Chariton River Valley. Its objectives were to determine the frequency of gullying in switchgrass fields and document A horizon depth and stable aggregate content. Gully frequency was assessed in 20 fields. Thirteen fields have one or more gullies, with most gullies extending more than 30 m in length and often having maximum depths exceeding 1 m. No correlation was found between the presence of gullies and current switchgrass stand quality. Attempts to monitor gully evolution failed because of the high shrink-swell properties of the soil. No relationship between soil type and gully development has yet been identified. We speculate gully formation results from the interplay between switchgrass physiology (a bunchgrass having slow establishment), local weather (noted for intense rainstorms), and limiting soil-landscapes (poorly-drained, steeply sloping, stratified profiles). Ongoing undercutting of existing switchgrass bunches was common, even in fields having excellent stand quality.

Stable aggregate content and depth of A horizons in switchgrass fields were each significantly greater than for adjacent row crop fields. Stable aggregate content in switchgrass fields averaged about 75%, which is twice that for adjacent row crop fields. The average thickness of A horizons in switchgrass fields is greater than for most other land uses in the Chariton River Valley. These observations suggest that long-term production of switchgrass can result in significant improvements in soil tilth and on-site environmental quality, provided the gullying previously discussed is controlled.

In summary, significant agronomic and environmental constraints exist when producing switchgrass in the Chariton River Valley. Most of these limitations can be overcome with proper agronomic management. When these limitations are overcome, yields are not limiting and soil tilth improves.

References listed

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